



Exploration of

Plasma-Jet Magneto-Inertial Fusion

1-D Burn Dynamics

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Goals of Present Research

- Use UW's 1-D radiation hydrodynamics code, BUCKY, to examine the burn dynamics of magneto-inertial fusion, with particular emphasis on
 - Shock physics,
 - Mach ≤ 20 liner velocity,
 - High-Z gas (e.g., argon) for liner's outer layer,
 - Fusion-product energy deposition,
 - Burning of liner's D-T inner layer, and
 - Ideal or non-ideal gas equations of state.
- Develop parametric understanding.
- Optimize MIF configurations.

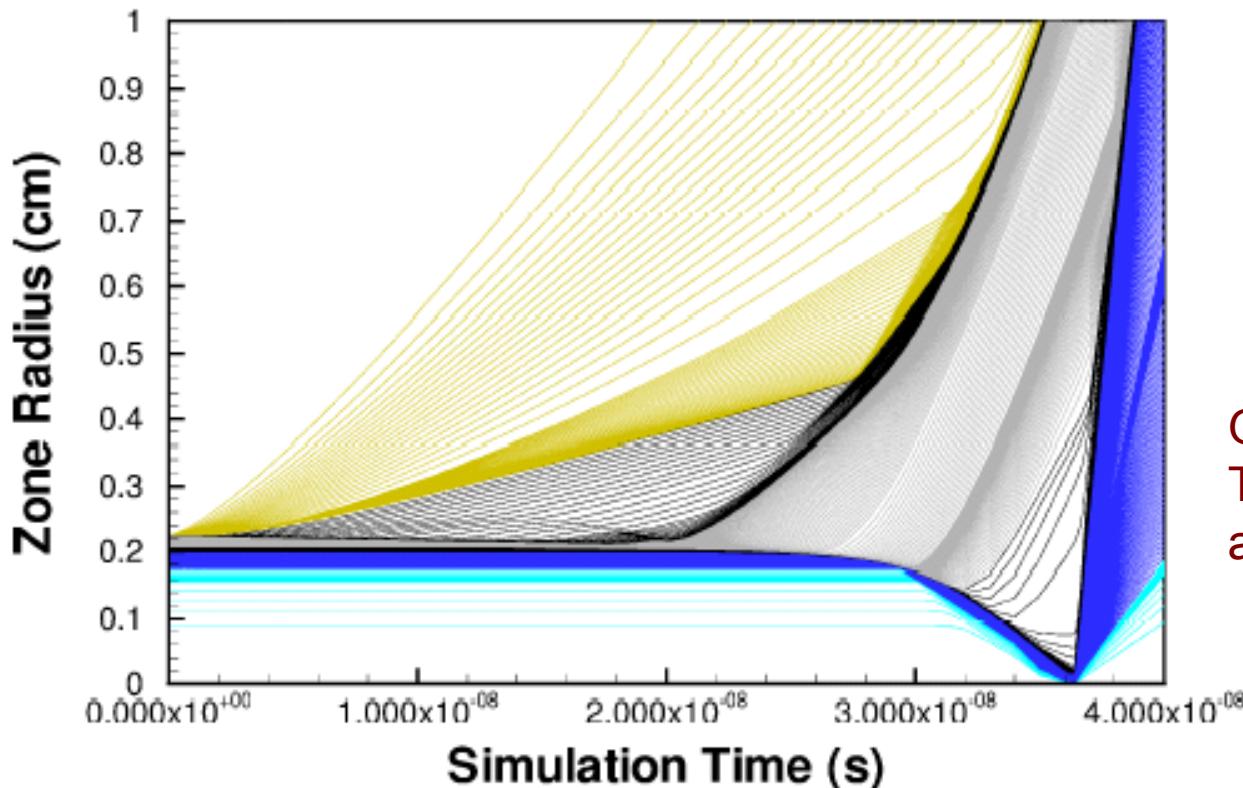


Features of UW's 1-D BUCKY Rad Hydro Code

- Lagrangian approach in planar, cylindrical, or spherical (used here) geometry
- Single-fluid equations of motion with pressure contributions from electrons, ions, radiation, and fast charged particles for D-T, D-D, and D-³He reactions
- Plasma energy transfer treated using either a one-temperature or two-temperature Maxwellian model, including PdV work and fast-ion (beam or target debris) energy deposition. Heating due to fast charged particles and neutrons during the fusion burn included.
- Charged particle reaction products transported and slowed using time-dependent particle tracking or local deposition. Fast ions from target micro-explosion debris tracked using a time-, energy-, and species-dependent stopping power model.
- Sophisticated equation-of-state (Sesame, UW EOS tables, etc.) capability.
- Benchmarked against many ICF problems.

Bucky Has Been Successfully Used to Simulate Many ICF Targets

- Figure shows Lagrangian constant-mass zones for a “tamped-target” HAPL (high average power laser) reactor study concept.
- Bucky results benchmark well against LASNEX runs of HAPL targets.



Generated by
Thad Heltemes
and Greg Moses

Features Added to UW's 1-D BUCKY Rad Hydro Code during the Present Project

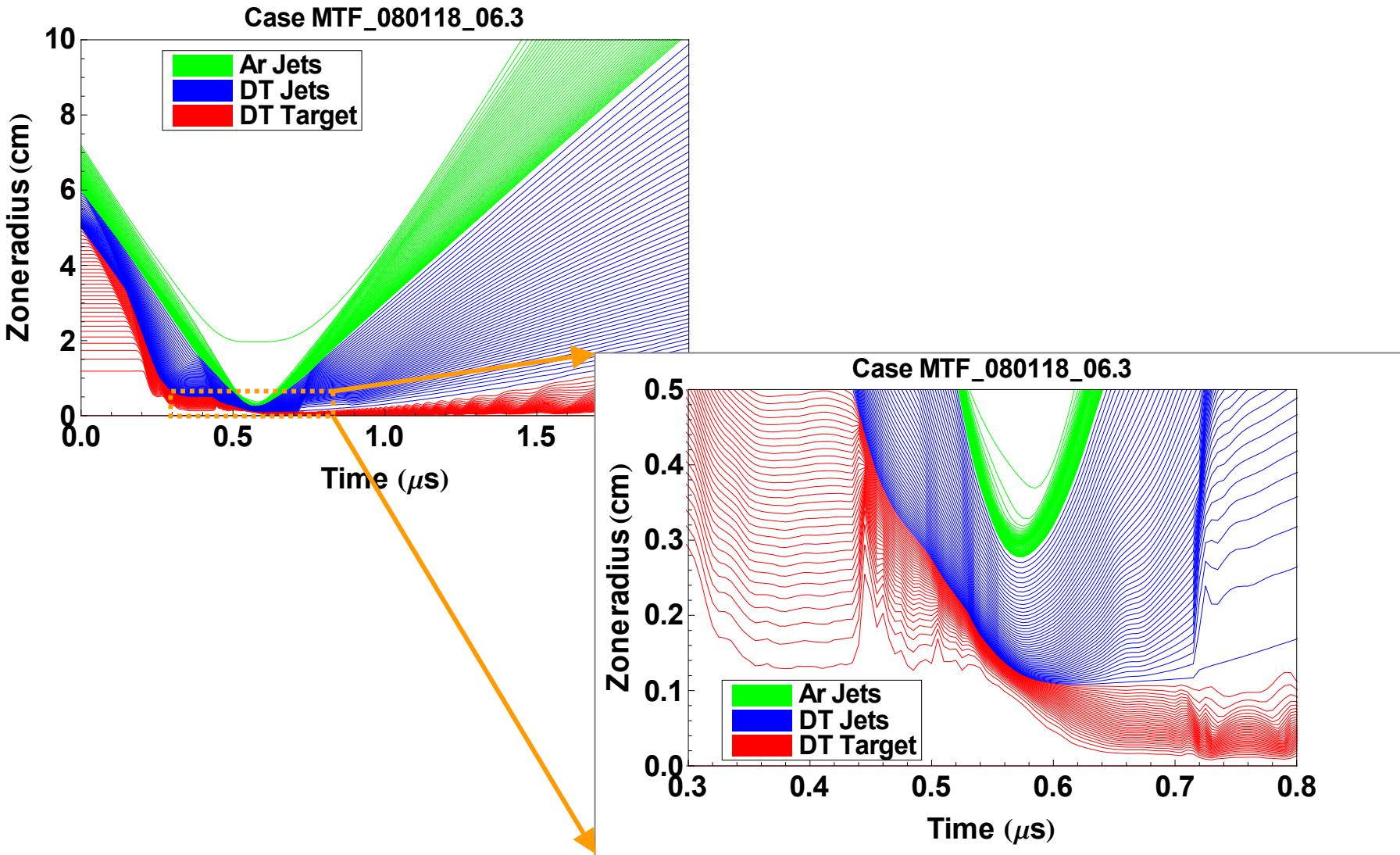
- Magnetic flux conservation ($B r^2 = \text{const}$ in magnetized target).
- Magnetic-field enhanced Braginskii thermal conductivities:

$$\kappa_{\perp e} = \frac{n_e k(kT_e) \tau_{ee}}{m_e} \left(\frac{4.66 \omega_{ce}^2 \tau_{ee}^2 + 11.92}{\omega_{ci}^4 \tau_{ii}^4 + 14.79 \omega_{ci}^2 \tau_{ii}^2 + 3.77} \right)$$

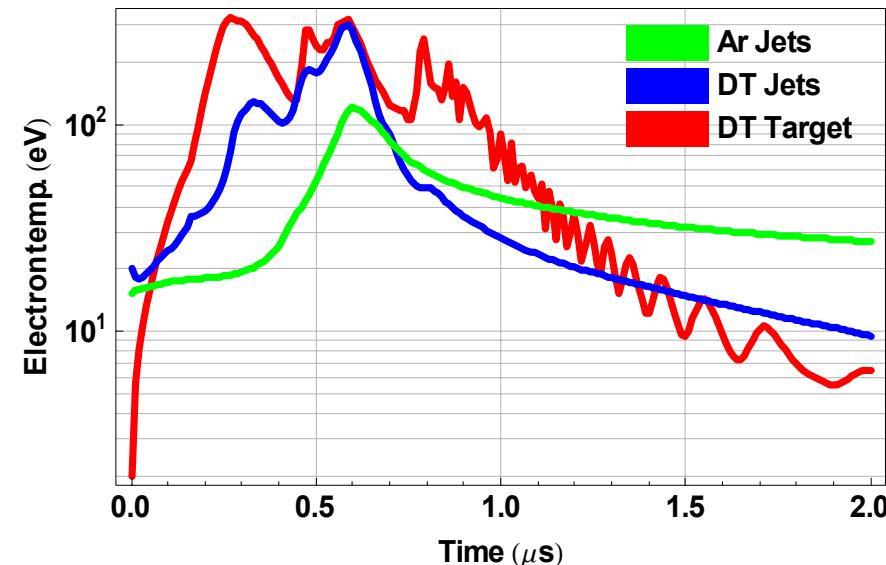
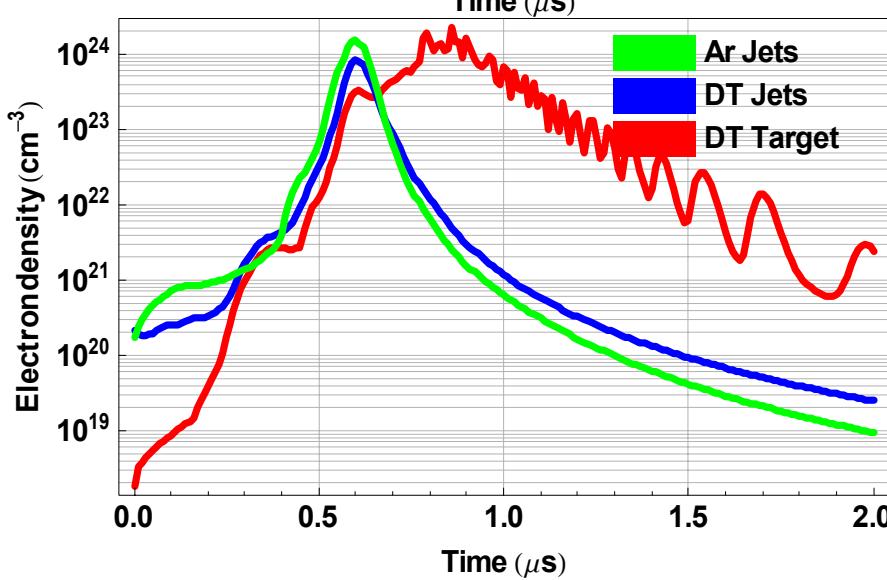
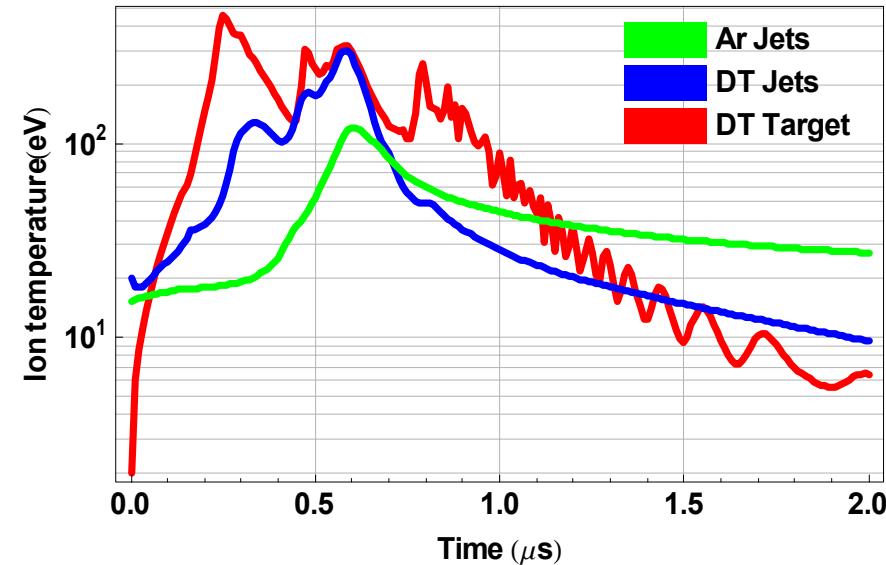
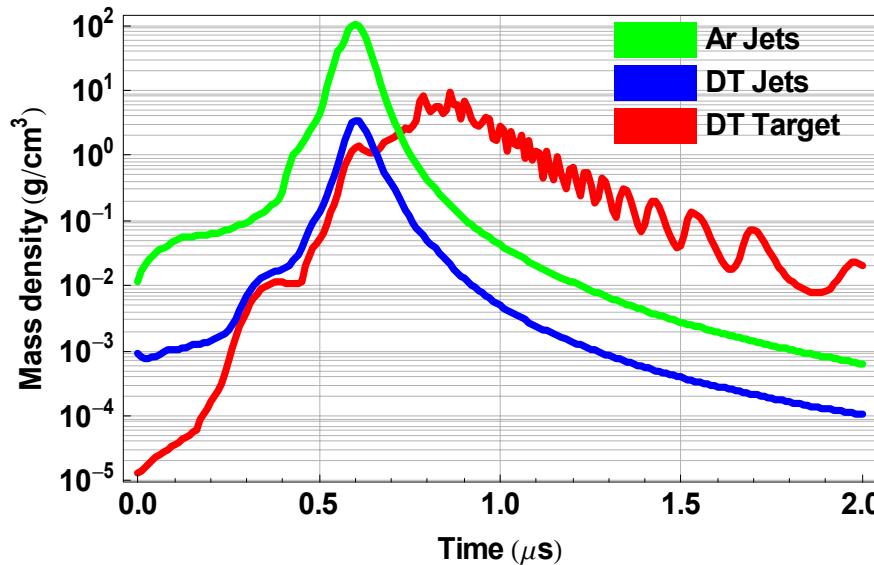
$$\kappa_{\perp i} = \frac{n_i k(kT_i) \tau_{ii}}{m_i} \left(\frac{2 \omega_{ci}^2 \tau_{ii}^2 + 2.64}{\omega_{ci}^4 \tau_{ii}^4 + 2.7 \omega_{ci}^2 \tau_{ii}^2 + 0.68} \right)$$

- Magnetic-field pressure ($B^2/2\mu_0$).
- B-field effects on alpha-particle energy deposition presently are bracketed by local deposition or $B=0$ time-dependent particle tracking.
 - A more sophisticated approach is under development.
- Mathematica post-processing interface.

Plots of Lagrangian Zone Radii vs. Time Give Valuable Information about the Shock Structure

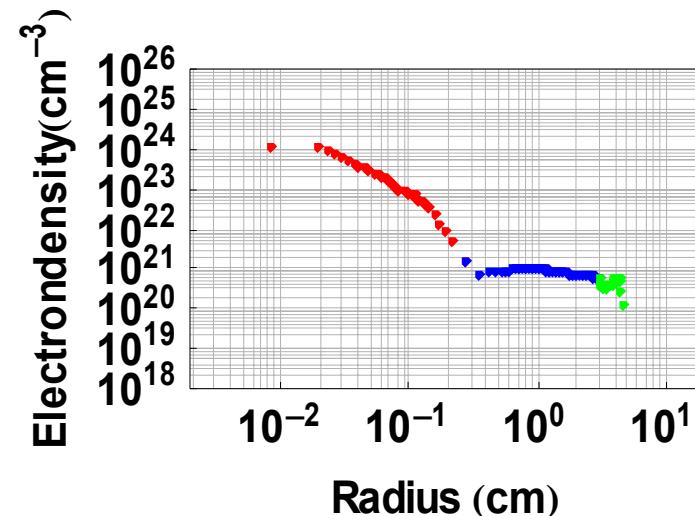
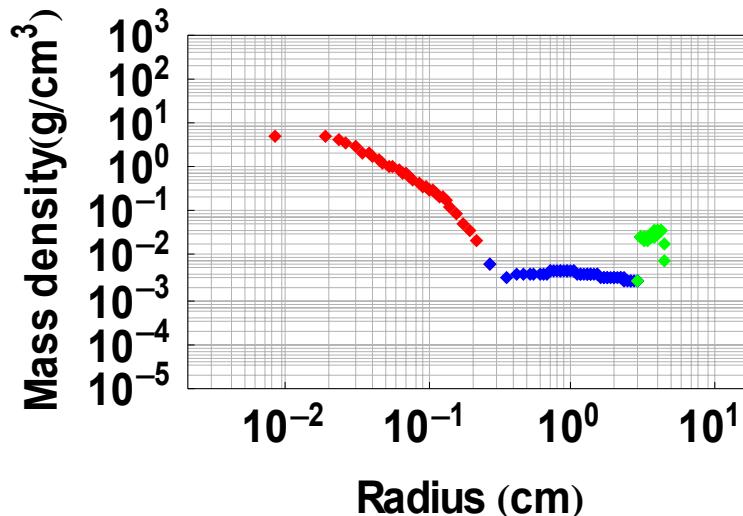
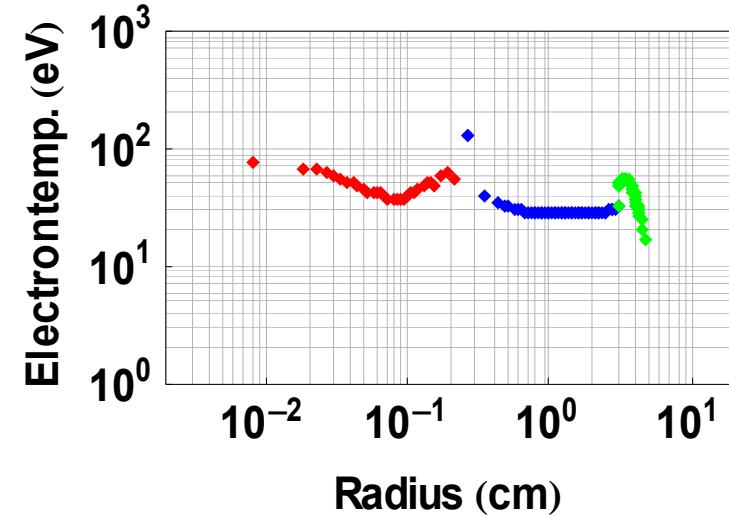
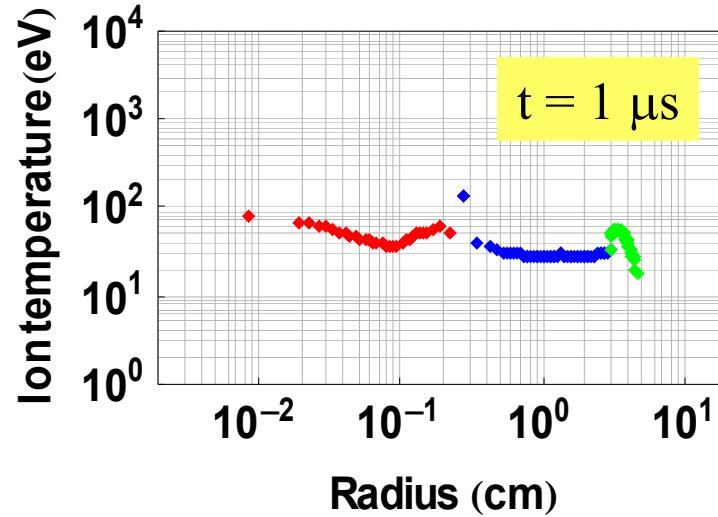


Selected Averaged Zone Parameters



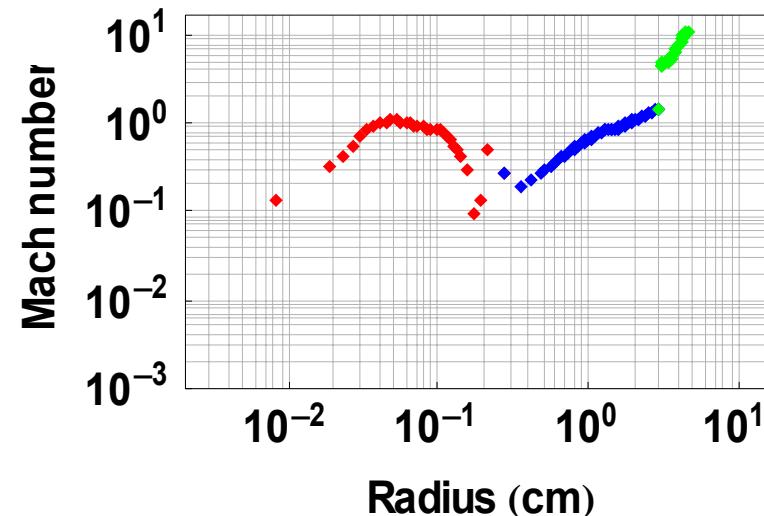
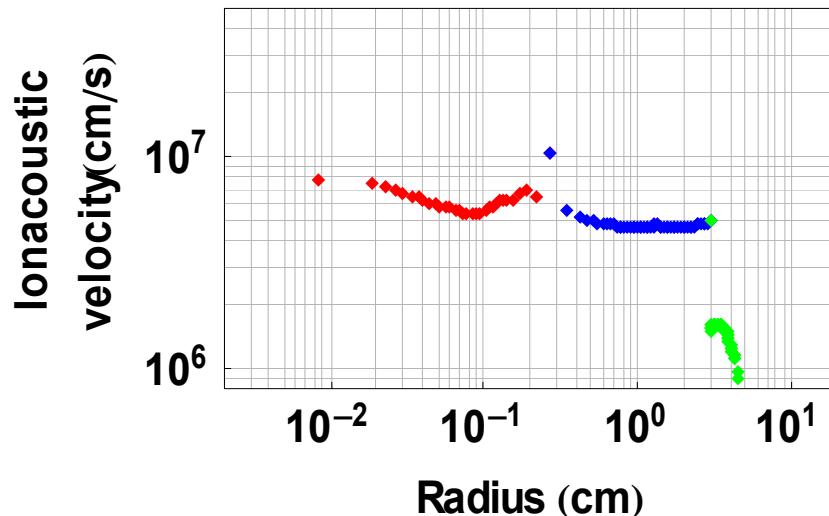
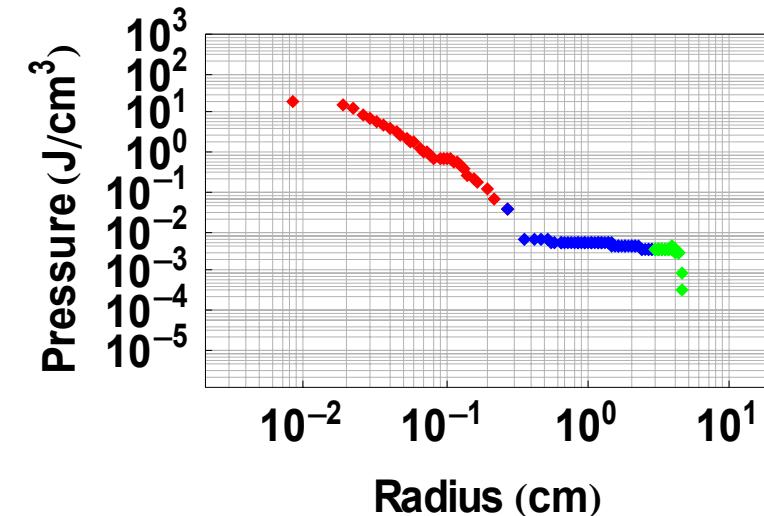
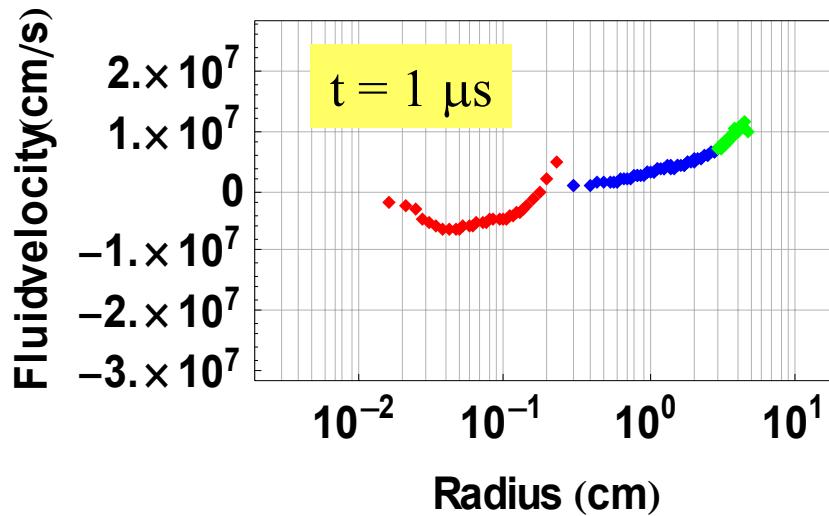
Temperature and Density Parameters versus Radius

- Mathematica can animate the parameters to examine zone evolution.



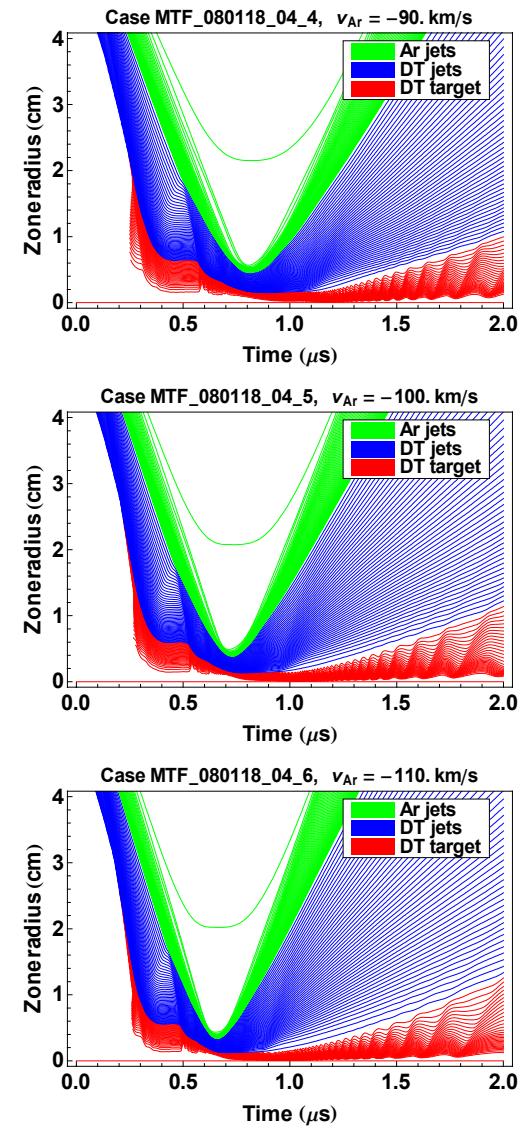
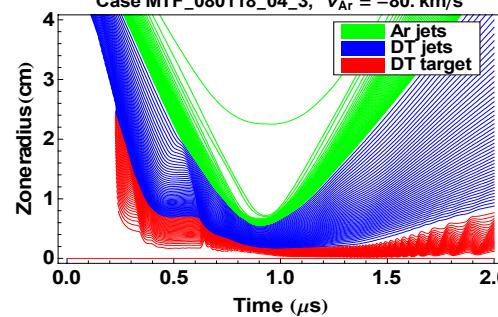
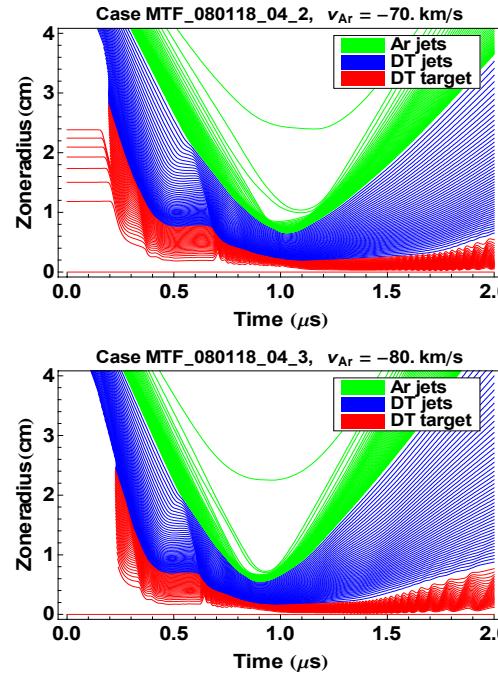
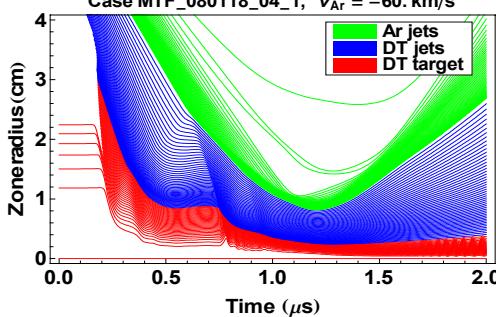
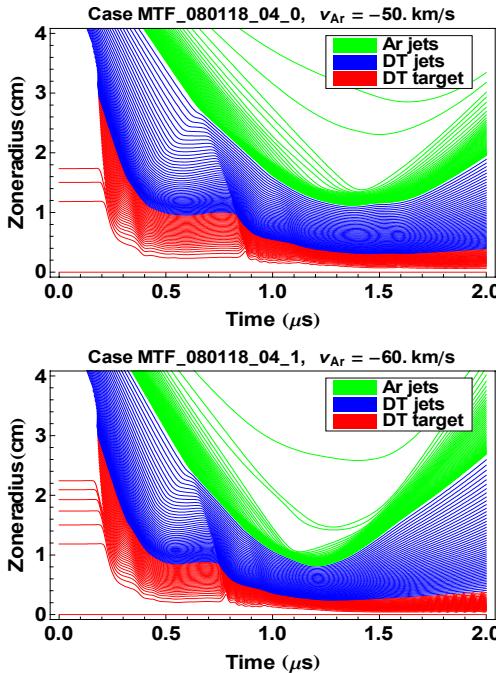
Velocity and Pressure Parameters versus Radius

- Mathematica can animate the parameters to examine zone evolution.



Parametric Cases Can Be Run on UW's Condor PC Network or ZEEP Workstation Cluster

- Post-processing with Mathematica.[®]
- Cases shown for $50 \text{ km/s} \leq v_{\text{Ar}} \leq 110 \text{ km/s}$:



Status

- BUCKY, UW's well-benchmarked 1-D radiation hydrodynamics code is being used to investigate magneto-inertial fusion parameter regimes.
 - Magnetic-field dependent thermal conductivity implemented.
 - Magnetic flux conservation implemented.
 - Magnetic-field pressure implemented.
 - Alpha particle energy deposition model in progress.
- Parameter space needs to be investigated more widely.
 - Tools for nearly automatic parametric runs and post-processing of the results have all been built.